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14. ABSTRACT The Field of Vision Test Operating Procedure provides the methodology by which testers quantitatively determine the fields of vision both above and below the horizon on each angle of azimuth around the vehicle for each operator.						
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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 3-2-812
DTIC AD No.

16 December 2009

FIELD OF VISION - VEHICLES

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1. SCOPE.

1.1 Purpose.

This Test Operations Procedure summarizes the field of vision (FOV) for the all crew positions of combat vehicles.

1.2 Background.

Analysis of the field of view for each crew member is particularly important for combat vehicles where effectiveness of equipment may depend largely upon the operator's ability to see his surroundings. The Commander's ability to detect targets and direct the crew's effort to engage is very important. Close-in vision should permit observation of the vehicle itself when looking downward and the sky when looking upward. Because of heavy protective shielding, combat vehicles have areas of restricted visibility which need to be quantified. Also, some combat vehicles require indirect or protected observation through various devices that accommodate the observers in their constricted positions. The FOV through these devices also needs to be quantified.

1.3 Limitations.

These procedures can be utilized for attaining FOV measurements of all crew positions of a combat vehicle with the understanding that the measurements will be limited by natural head and eye rotation limits.

2. FACILITIES AND INSTRUMENTATION.

- a. A turning circle.
- b. Two stadia rods or some instrument that provides measurement references from the ground to above the horizontal line of sight of the user.
- c. Tape measure.
- d. Small cones or similar distinguishable markers.

Note: It is recommended that human observer be replaced with an imaging system that can provide point measurements, azimuth readings, and elevation reading similar to the instrumentation used by the Human Factors Group at Aberdeen Test Center.

3. REQUIRED TEST CONDITIONS.

3.1 General.

a. Location. Testing must be performed on a level area such as a large concrete turning circle. The radius of the turning circle should be larger than the length of the vehicle under test. This is done to ensure all crew positions can be centered on the turning circle without the ends of the vehicle impeding the edge of the turning circle. Mark the circle with radial lines from the center point of the circle outward at 10 degree intervals.

b. Orientation. Position the vehicle such that the longitudinal axis of the vehicle is aligned with the 0 degree point of the turning circle. The portion of the vehicle which houses the designated crew position under test should be centered on the center point of the turning circle.

c. Measurements. Measurements should be taken in 10 degree intervals. Measurements taken which are at intervals less than the designated 10 degree intervals shall be interpolated.

3.2 Pre-test.

a. Position the vehicle on the turning circle such that the crew position under test is centered above the center point of the turning circle.

b. Use a tape measure to measure the eye height of the seated observer to the ground for a 95th percentile male and a 5th percentile female. The dimensions of the vehicle should also be taken.

4. TEST PROCEDURES.

4.1 Minimum Ground Intercept Visibility.

Determine the minimum distance at which the operator can visually identify the ground closest to the vehicle. It is recommended that the FOV for each window configuration be plotted separately.

a. Define the closest visible ground intercept points, lateral angle, and distance from origin for each point measured. When the ground is not visible, record the lowest stadia rod reading that can be seen. Obstructions should be outlined by taking readings at all corners of the obstruction.

b. Measurements should be taken in 10 degree intervals. Measurements taken which are at intervals less than the designated 10 degree intervals shall be interpolated.

c. Calculate the visual angle of declination and the ground intercept distance from the eye height point. The visual angle of declination can be easily calculated by looking at the FOV projection as a right triangle. The vertical distance between the ground and the observer's eye is the height of the triangle. This distance represents the eye height or Eh . The horizontal distance

from the center of origin out to the point where the ground intercept makes contact with the ground represents the ground distance or G_d . The ground intercept is the segment that connects the two lines. When the values of both distances are known the visual angle of declination or Θ can be solved using the Arctangent of the eye height over the ground distance.

$$\Theta = \arctan(E_h / G_d)$$

If the ground is not visible due to performing this method in restricted areas such as enclosed buildings and a stadia rod reading must be taken, the process will be slightly altered. The stadia rod reading must be subtracted from the eye height. This new calculation will serve as the height of the triangle. The horizontal distance from the center of origin to the stadia rod will serve as the base of the triangle. Although the triangle is different in size the angle remains the same. This yields:

$$\Theta = \arctan((E_h / S_r) / S_d)$$

where S_r is the stadia rod reading and S_d is the Stadia rod distance from the center of the origin. Once the visual angle of declination is calculated the ground intercept and ground distance values can be calculated. The ground intercept value can be defined as:

$$G_i = E_h / \sin \Theta$$

G_i represents the Ground Intercept value.

d. Plot the polar coordinates using the ground intercept as the radius and the lateral angle as the angular coordinate.

4.2 Forward Looking Visibility.

Determine the maximum left/right lateral angles and the corner edges of each window and obstruction that can be seen by the observer while retaining visual acuity on the zero degree mark.

- a. The observer is limited to 0 degrees of head elevation and a maximum lateral head rotation not to exceed 60 degrees with additional lateral eye rotation not to exceed 35 degrees.
- b. Record the maximum ground intercept edge point from the stadia rod reading. This edge point represents the maximum ground intercept within the turning circle that can be seen by the observer from the referenced eye height position.
- c. Using one stadia rod as a reference marker at 0 degrees use the other stadia rod to record the closest visible ground intercepts, lateral angles, and distance from origin for each point measured. Record the measurements for the corner edges of all windows and obstructions within the predetermined Forward Looking FOV.

- d. Calculate the ground intercept of each point and plot the polar graph.

4.3 Total Lateral Visibility.

Determine the maximum lateral angles that can be seen by the observer with 0 degrees of head elevation and the maximum acceptable head and eye rotation based upon Figure 2 of MIL-STD 1472F^{1*}. This angle represents the total field of vision that can be seen by the observer.

- a. The observer is limited to a maximum lateral head and eye rotation not to exceed 95 degrees to the left or right of the 0 degree reference.
- b. Record the lowest and highest stadia rod reading that can be seen from the corners of each window. Record the lateral angles, and distances from origin. Readings should also be taken for the corners of all obstructions.
- c. Calculate the ground intercept of each point and plot the polar graph.

5. DATA REQUIRED.

The following data shall be recorded:

- a. Minimum distance that can be seen by the observer.
- b. Lateral angles.
- c. Visual angle of declination.
- d. Ground distance.
- e. Photographs. Photographs of the test vehicle, its window configuration, and any obstructions that are present should be taken.

6. PRESENTATION OF DATA.

Field of vision data shall be plotted on polar graphs with the FOV shown for all windows. Analysis of plotted data is based upon vehicle specifications and its effect on the visibility of the individual crew members. Because there are several calculations to be made, it is recommended that an Excel spreadsheet be created to do the calculation. Figure 1 is a template of an Excel sheet used to record data and Figure 2 is a polar plot graph by the excel sheet.

* Superscript numbers correspond to those in Appendix C, References.

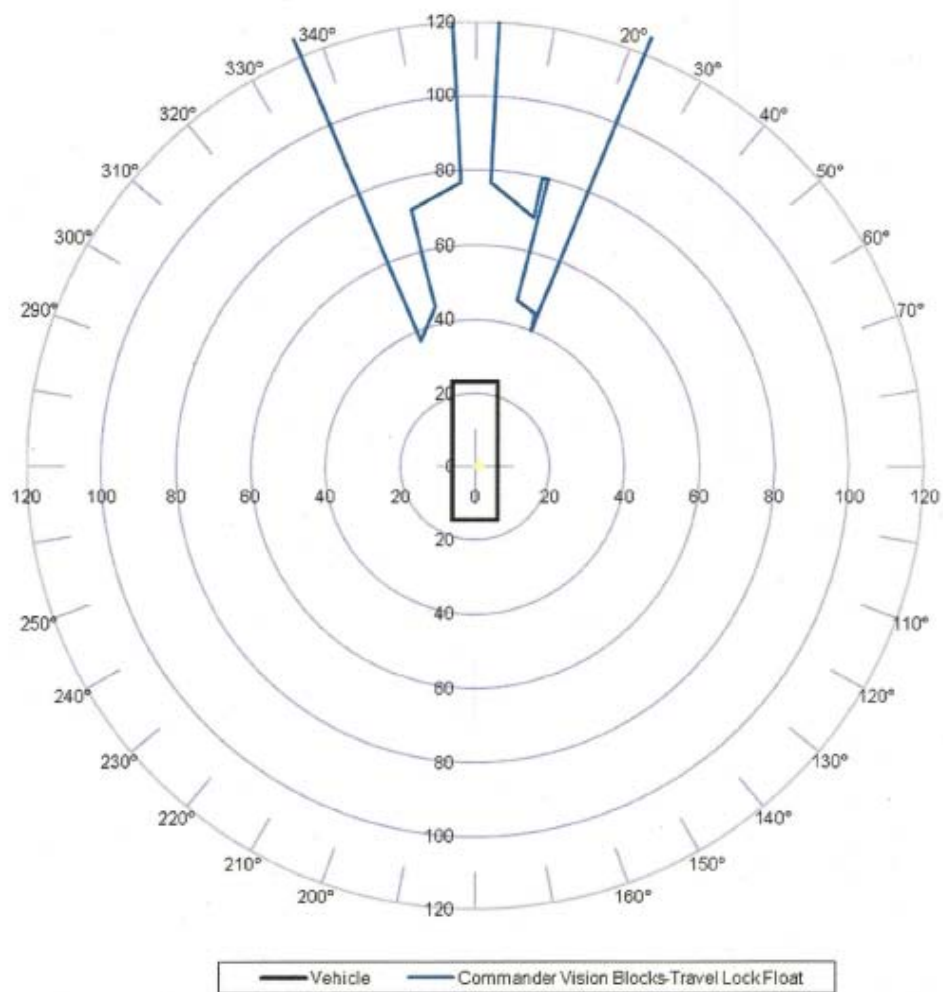
FOV/FOF

	feet
Eye Height:	
Stadia distance:	
vehicle width:	
vehicle length:	
drivers position width:	
drivers position length:	

	feet
Max radius:	120
Interval:	20
Trailer	
Trailer width:	
Trailer length:	
Trailer gap:	

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Figure 1. Excel Template.



No ground intercept @ 0°, forward visibility 35°

Figure 2. Example of Polar Plot.

APPENDIX A. GLOSSARY.

Arctangent: mathematical function that produces the visual angle of declination when provided an eye height and ground distance.

Eye Height: distance from the crew member's eye to the ground or surface below the vehicle.

Ground distance: the horizontal distance from the center of origin out to the point where the ground intercept makes contact with the ground.

Stadia Rod: a graduated wooden or aluminum rod, the use of which permits the determination of differences in elevation.

APPENDIX B. ABBREVIATIONS.

Arctan	=	Arctangent
E_h	=	eye height
FOV	=	field-of-view
G_d	=	ground distance
G_i	=	ground intercept value
MIL-STD	=	Military Standard
S_d	=	stadia rod distance from the center of the origin
S_r	=	stadia rod reading
TOP	=	Test Operations Procedure
Θ	=	visual angle of declination

APPENDIX C. REFERENCES.

1. Military Standard (MIL-STD) 1472F, Department of Defense Design Criteria Standard, Human Engineering, 23 August 1999.

For information only:

- a. SAE Standard J1050, Surface Vehicle Recommended Practice Measuring the Driver's Field of View, January 2003.

Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Test Business Management Division (TEDT-TMB), US Army Developmental Test Command, 314 Longs Corner Road Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: US Army Aberdeen Test Center (TEDT-AT-WFS), 400 Collieran Road, Aberdeen Proving Ground, MD 21005-5059. Additional copies can be requested through the following website: <http://itops.dtc.army.mil/RequestForDocuments.aspx>, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.